Correlation between Ciliary Muscle Thickness and Myopia in Saudi Females using Visante Anterior Segment Optical Coherence Tomography

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Introduction
Myopia is the most common ocular disorder. There is marked increase in the incidence of myopia among school children until the age of 15 years [1]. In Saudi Arabia, myopia has been reported to be the most predominant type of refractive error among 6-14 years school children in a study achieved in Al Hassa [2]. Not all Authors found a clear correlation between myopia and work closely [3].

Rehm (2015) [4] stated that prolonged near work is the leading cause of development of myopia. On extended near work chronic ciliary muscle spasm induces irreversible elongation of the axial length producing more myopia. Several studies documented relatively thicker ciliary muscle in myopic eyes [5,6] while another study did not find a significant relation between myopia and ciliary muscle thickness (CMT) [7].

Visante Anterior Segment-Optical Coherence Tomography (AS-OCT), a non-contact time-domain system, has the ability to capture and analyze cross-sectional scans of the anterior segment of the eye. It can be used to evaluate CMT in myopia [8].

The aim of this study was to evaluate the correlation between ciliary muscle thickness and myopia in Saudi females using AS-OCT.

Study Design
This study was a prospective, non-randomized, cross-sectional, observational, and
Subjects and Methods

This study included 65 Saudi females (65 right eyes) from College of Applied Medical Science (female section), King Saud University, Riyadh and Saudi Arabia. The age range is 18 to 25 years (mean: 20.82 ± 1.69). Eyes were divided into myopic eyes (-5.00 to -0.63 D) (MSE ≥ -0.50 D) and non-myopic eyes (-0.50 to +4.50 D) (MSE ≥ -0.50 D). Subjects with any previous history of ocular surgery, trauma or pathology, ocular medication and astigmatism >1.75 D were excluded from the study.

All subjects underwent a complete ophthalmic examination including visual acuity assessment using Snellen chart, intraocular pressure measurement using air puff tonometer, slit-lamp biomicroscopy, and fundus examination. Measurement of refractive error and central corneal curvature (CCC) was performed using auto-keratorefractometer (Topcon, TRK.1P). Five measurements of refractive error were obtained, which were averaged and transformed to mean spherical error (MSE) (sphere power + 0.5 x cylinder power). In addition, measurement of axial length (AL) and anterior chamber depth (ACD) was performed by IOL Master 500 (Carl Zeiss, Meditec AG).

In this study CMT for right eye only was measured. Imaging the ciliary muscle in its normal state without removing its tonus was achieved and transformed to mean spherical error (MSE) (sphere power + 0.5 x cylinder power). In addition, measurement of axial length (AL) and anterior chamber depth (ACD) was performed by IOL Master 500 (Carl Zeiss, Meditec AG).

By means of the Visante’s ‘analysis’ mode, a sequence of CMT measurements for both temporal and nasal sections (in micrometer) were achieved. All measurements were taken manually using the procedure designated by Buckhurst, et al. [9] Sceral spur provides the main reference point for all measurements of ciliary muscle and after its determination, a 1 mm calliper was protracted along the interface between the sclera and the ciliary muscle. Measurement of CMT at 1 mm (from the scleral spur) was performed by locating a second calliper orthogonal to local scleral curvature and the distance between the outer ciliary muscle-scleral boundary and inner surface of ciliary pigment epithelium was verified. To measure CMT at 2 mm and 3 mm, two more callipers were positioned sequentially 1 mm along ciliary muscle-scleral boundary and CMT was measured as stated previously [9] (Figure 1).

Statistical Analysis

Descriptive statistical analysis was performed using SPSS (Version 22, SPSS Inc., USA) (mean, standard deviation [SD]) for demographics and clinical parameters. Paired T-Test was performed to assess the difference in CMT between nasal (NCMT) and temporal (TCMT) measurements for all eyes and then separately for myopic and non-myopic eyes. However, unpaired T-Test was used to find the differences between myopic and non-myopic eyes. Additionally, Pearson’s correlation coefficient was calculated to evaluate the correlation between CMT and ocular biometry for all eyes and then separately for myopic and non-myopic eyes. P value <0.05 was considered statistically significant.

Results

This study included 65 eyes (33 myopic eyes and 32 non-myopic eyes). Descriptive statistical analysis for all eyes, including mean ± SD of age, MSE, CCC, AL, ACD and nasal (NCMT) and temporal (TCMT) measurements (CMT1, 2, and 3 correspond to measurements at 1, 2, and 3 mm posterior to the sclera spur) were presented in Table 1. Regarding comparison of CMT between temporal and nasal sectors in all eyes (myopic and non-myopic eyes), there was a statistically significant difference between TCMT (TCMT2, TCMT3) and NCMT (NCMT2, NCMT3) (P<0.005). On the other hand, there was no
The non-myopic eyes showed a statistically significant positive correlation between AL and TCMT2, TCMT3, NCMT1, NCMT2 (P<0.05). Alternatively, there was a statistically insignificant negative correlation between MSE and all measures of CMT (P>0.05). Also, there was a statistically insignificant positive correlation between CCC and CMT, except NCMT3 (P>0.05). In addition, ACD demonstrated a statistically significant positive correlation with CMT1, 2 and negative correlation with CMT3 respectively (P<0.05).

Myopic eyes showed a statistically insignificant positive correlation between AL and all measures of CMT (P<0.05) except for CMT1 (P<0.05). In addition, there was a statistically insignificant positive correlation between AL and all measures of CMT (P<0.05) except for NCMT3 (P=0.004). Also, there was a statistically insignificant negative correlation between AL and TCMT and statistically insignificant positive correlation between CCC and NCMT (P<0.05). Additionally, there was a statistically insignificant positive correlation between ACD and all measures of CMT (P<0.05) except for CMT3. Correlation of CMT and ocular biometry using Pearson’s Correlation Coefficient for all eyes was demonstrated in Figure 4.

**Discussion**

The aim of this study was to evaluate the correlation between CMT and myopia in Saudi females using AS-OCT. The difference between male and female in the structure of ciliary muscle was not investigated before except by Saigal, RN 2016, [10] who found the ciliary muscle to be significantly longer in males, compared to females. However, the ciliary muscle was thicker in females. Its thickness was measured proportional to the overall curved ciliary muscle length. Further investigations are recommended to demonstrate this difference.

Regarding comparison of CMT between temporal and nasal sectors in all eyes, there was a statistically significant difference between TCMT (TCMT2, TCMT3) and NCMT (NCMT2, NCMT3). However there was no statistically significant difference between TCMT1 and NCMT1. These findings agreed with Buckhurst et al. study [10] that demonstrated a tendency for a thicker CM temporally than nasally for both CMT2 and CMT3 but not for CMT1. In addition, Sheppard and Davies study [11] documented that the ciliary muscle was thicker (P<0.001) and had a more contractile response on temporal than nasal side. It has been suggested that the recognized morphological asymmetry in CM may play a biomechanical role in refractive error development [11,12].

In the current study, concerning comparison of CMT between myopic and non-myopic eyes, there was a statistically significant difference in CM (TCMT2, TCMT3), and in NCMT3. These correlations were statistically significant between TCMT1 and NCMT1 in non-myopic and myopic eyes (P=0.089) (P=0.371) respectively.

Concerning comparison between myopic and non-myopic eyes, there was a statistically significant difference in TCMT (TCMT2, TCMT3) (P=0.005, 0.015). Alternatively, there was no statistically significant difference in TCMT (TCMT2, TCMT3) (0.005, 0.015). On the other hand, there was a statistically significant difference in NCMT3 (P=0.001). Though, there was no statistically significant difference in NCMT1, NCMT2 (P>0.05). Difference in ciliary muscle thickness between myopic and non-myopic eyes was demonstrated in Figures 2 and 3.

**Table 2:** Descriptive statistical analysis of mean values of nasal and temporal CMT (a) both myopic and non-myopic (b) non-myopic and (c) myopic eyes. (*) P value < 0.05. (**) P value < 0.001.

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Figure 2: Temporal Ciliary Muscle Thickness (TCMT) measurements in myopic eye (a) and in non-myopic eye (b)
Figure 3: (a-f) Box and whiskers plot (median and interquartile range) for temporal and nasal CMT (1, 2, and 3 mm). The whiskers represent the highest and lowest values that are not outliers or extreme values. Outliers or extreme values are represented by circles beyond the whiskers.

Figure 4: Pearson coefficient correlations between ciliary muscle thickness and ocular biometrics (a) For both myopic and non-myopic eyes (n=65) (b) For myopic eyes (n=33) (c) For non-myopic eyes (n=32).
results matched with many studies that demonstrated thicker ciliary muscle in myopic eyes [6,13]. Also, Buckhurst, et al. [9] and Pucker, et al. [14] found a statistically significant thicker CMT2 and CMT3 in myopic eyes, but not CMT1. The reason of greater CMT in myopic eyes is still vague. Mutti, et al. [15] recommended that accommodative insufficiency in myopic children may be explained by deficient ciliary muscle contraction due to muscle hypertrophy.

As regards correlation of CMT and ocular biometry using Pearson’s Correlation Coefficient in our study; non-myopic eyes showed a statistically significant positive correlation between AL and TCMT2, TCMT3, NCMT1, NCMT2 and insignificant negative correlation between MSE and all measures of CMT. However, myopic eyes demonstrated a statistically insignificant positive correlation between AL and all measures of CMT except for CMT1 as well as between MSE and most measures of CMT. Buckhurst et al. study [9] documented that TCMT1, TCMT2, NCMT1 and NCMT2 in non-myopic eyes presented a statistically significant positive correlation with AL and negative correlation with MSE. On the other hand, most measures of CMT in myopic eyes in their study did not reveal a statistically significant relationship with AL and MSE except for NCMT2 with AL.

Regarding correlation between CMT and ACD in our study, all eyes demonstrated a statistically significant positive correlation with (CMT2, 3) but insignificant positive correlation with CMT1. These findings matched with Buckhurst, et al. [9] that found a statistically significant positive correlation between ACD and both temporal and nasal (CMT2 and CMT3). Normally during eye growth, there is equatorial stretch with equatorial expansion accompanied by deepening of anterior chamber and thinning of crystalline lens [6]. Therefore, the equatorial stretch is restricted by ciliary muscle. Consequently, correlation of ACD with CMT should be predicted [16].

Concerning correlation between CMT and CCC in the present study, there was a statistically insignificant positive correlation in non-myopic eyes, except NCMT3 and negative correlation in myopic eyes. These findings disagreed with Buckhurst, et al. study [9] who detected a statistically significant positive correlation between CCC and CMT1 in myopic eyes only.

Conclusion

This study documented increased CMT in myopic eyes. Future studies are recommended to evaluate structural characteristics of the ciliary muscle in the context of 3-D morphological features of the globe that are better indicators of architectural changes that occur in myopia.

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Declaration of Interest

All authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest (such as honoraria; educational grants; participation in speakers’ bureaus; membership, employment, consultancies, stock ownership, or other equity interest; and expert testimony or patent-licensing arrangements), or non-financial interest (such as personal or professional relationships, affiliations, knowledge or beliefs) in the subject matter or materials discussed in this manuscript.

References


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